SYNOPSIS

NUTRACEUTICAL POTENTIAL AND CYTOTOXIC ACTIVITY OF FRESH AND PROCESSED TAMARILLO (*Solanum betaceum* Cav.) EXTRACTS IN CERVICAL CANCER CELL LINES

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CHAPTER I- INTRODUCTION

Noncommunicable diseases (NCDs) currently account for majority of death worldwide, with cancer projected to become the primary cause of death and the foremost obstacle to enhancing life expectancy throughout world in the 21st century (Ferlay *et al*., 2018). According to the International Agency for Research on Cancer and the World Health Organization (2022), cervical cancer ranks as the fourth most common cancer among women worldwide, with approximately 660,000 new cases and 350,000 deaths reported annually. Human Papillomavirus (HPV) is considered as the etiologic agent of cervical cancer. In India, cancer of the cervix uteri is the third most common cancer with an incidence rate of 18.3% (123,907 cases) and the second leading cause of death with a mortality rate of 9.1% as per GLOBOCAN 2020. There were 8,534 estimated cases of cervical cancer incidence in Tamil Nadu in 2023, according to data from the Government of India. According to the Tamil Nadu Cancer Registry Project (TNCRP, 2018), cervical cancer accounted for **17.7%** of all cancers in the Nilgiris district. In 2018, a total of **341** cancer cases were reported in the district. More recent hospital records (2023–2024) indicate **41** new cases of cervical cancer within a one-year period, with an incidence rate approaching one case per day, underscoring its persistent public health burden in the region. Food supplements play an important role in maintaining a healthy body by providing essential nutrients necessary for various metabolic processes (Shilpi *et al.,* 2019). People were consuming plant food as a medicine since certain foods can have the medicinal properties and be used to promote the health and wellbeing and also plant foods were used a traditional medicine as Ayurveda prescribed specific foods to prevent or treat various ailments. Regular consumption of plant foods helps to maintain overall health of the human and it potentially prevent diseases (Leena *et al.,* 2021).

Tamarillo is originated from central state of South America and also grown in New Zealand, Brazil, Argentina and Colombia. The exact birthplace of the tamarillo (*C. betacea*) remains a mystery. In New Zealand, it is a niche fruit crop. Tamarillo thrives in Mediterranean climates, making it a promising new fruit crop in suitable regions (Shah *et al.,* 2022). In Nepal, it is a popular homegrown vegetable. Similarly, Australians have been growing it in Queensland

and New Guinea for many years. In the USA, California cultivates it, while Florida sees occasional potted or indoor growth. Greenhouses also prove successful for tamarillo production. In India, it is being cultivated in Sikkim, Darjeeling, Tamil Nadu, Meghalaya and other northeastern states. In this study tamarillo was procured from local farms of Gudalur, a town at the Nilgiris District of Tamil Nadu. In the Nilgiris district, tamarillo (*Solanum betaceum* Cav.) is traditionally consumed for its rich vitamins content, which is believed to enhance immune function and contribute to disease prevention.

Tamarillo can be consumed in many ways and can be cooked in different methods. Ripe tamarillos are eaten fresh either halved and scooped. Optimal flavour and aroma are achieved in fully mature, ripened fruits. Peeled slices offer a delightful addition to desserts. Salads gain a vibrant touch with tamarillo slices while seasoned slices can be used as sandwich fillings or blended with cream cheese for a flavourful spread (Lim, 2020). Unripe tamarillos find use in chutneys, curries and sambals alongside onions and apples. Peeled and sliced fruit can be transformed into jam with lemon rind, juice and sugar. The consumption of fruits and vegetables is linked with human well-being and many organizations including World Health Organisation and Food and Agricultural Organisation suggested to improve the consumption of fruits and vegetables in everyday meal. Steaming was the ideal cooking method that better preserves the nutrients from fruits and vegetable processing (NT de Castro *et al.*, 2020). The market price of tamarillo will vary based on the season and regions and the price ranges from Rs.60-100 per kg.

Objectives of the study

Focus on the research gap to address the limited research on tamarillo as identified in the literature review this investigation proposes the following objectives:

Primary objective

- To study the nutraceutical potential and cytotoxic activity of fresh and processed tamarillo (*Solanum betaceum* Cav.) extracts in cervical cancer cell lines.

Secondary objectives

To

- Subject the tamarillo into different drying and cooking methods.
- Analyse the nutrient composition and retention of fresh and cooked Tamarillo.
- Identify functional groups and quantify phytochemicals.

- Study the antioxidant activity of fresh and processed tamarillo extracts.

CHAPTER II- REVIEW OF LITERATURE

This chapter composed of literature on cancer, cervical cancer, *Solanum betaceum* Cav., its nutritional, phytochemical constituents, bioactive compounds, biological activities related to fresh and processed tamarillo in cancer cell lines.

CHAPTER III - METHODOLOGY

The methodology of the study is presented as follows;

1. Collection of fruit and plant authentication

Fresh and ripened tamarillo (*Solanum betaceum* Cav.) were procured from a farm at Gudalur, a town in the Nilgiris District of Tamilnadu, India. Tamarillo was authenticated and certified by taxonomist at Botanical Survey of India, Tamil Nadu Agricultural University (TNAU), Ministry of Environment, Forest and Climate Change, Coimbatore, India (accession numbers: BSI/SRC/ 5/23/2023-24/Tech-172). Taxonomically the fruit was identified as *Solanum betaceum* Cav.- SOLANACEAE. The research design and the procedures used in the study were submitted for scrutinization and approval to the Institutional Human Ethical Committee of Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore and Ethical Clearance approval no AUW/IHEC/FSN-22-23/XMT- 8 was obtained.

2. Processing of Tamarillo

The procured tamarillo was separated into whole fruit, flesh, fruit chutney, juice and fruit peel for further processing. Drying is the best method of preserving fruits, vegetables and herbs. It helps to remove water from the sample, applying heat to the sample, solid or liquid samples resulting in dried solid samples with reduced sample raw-material volume and weight (Calin *et al*., 2020). The study carried out five different types of drying namely sun drying, cabinet drying, freeze drying, shade drying and nano spray drying. Diverse cooking methods of the sample were applied based on the two categories i.e., Moist heat methods including Boiling, Simmering, Steaming and Pressure cooking and Dry heat methods including Shallow frying, Stir frying, Roasting and Sauteing. The weight of the samples before and after cooking was noted for 50 g of samples.

3. Sensory Attributes, Nutritional composition and phytochemical profile of fresh and processed tamarillo

Sensory evaluation was conducted for fresh fruit, tamarillo chutney, juice and cooked tamarillo with 30 semi trained panel members using 9-point hedonic scale ratings at Food Sensory Evaluation Centre, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore. Nutrient composition was analysed for all the fresh and processed of all cooking and drying methods followed by AOAC method. True Retention Method Formula was used to calculate the percentage of nutrient retention in each cooking method for tamarillo (USDA, 2007).

All fresh and processed samples were ultrasonicated at 50-60 degree Celsius for 20 minutes with aqueous, ethanol and methanol solvents (Isidore *et al.,* 2021). Aqueous, ethanol and methanol solvents were used for screening of phytochemicals with standard procedures (Altemimi *et al.,* 2017). Methanol extracted samples were well solubilised, it was considered as good extraction, and it has the ability to dissolve wide range of compounds and stable in drug formulations. Fourier Transform Infrared Spectroscopy, is an analytical technique used to identify organic and inorganic materials (Miguel *et al.,* 2023). FTIR spectra were obtained for the fresh and processed fruit with methanol extracts. The fresh tamarillo fruit extract was effectively prepared using methanol and ultrasonic extraction to ensure optimal phytochemical release.

The antibacterial effects of tamarillo samples were assessed using the well diffusion method with Gram-positive (Staphylococcus aureus,) and Gram-negative (Escherichia coli) strains. These are the most common microorganism which causes the G.I tract infections. The extracts and Gentamicin (standard antibiotic) were added to the wells, with methanol as a negative control. The plates were incubated at 37°C for 24 hours, and the zones of inhibition were measured for the different concentrations (Suganya *et al*., 2022). Microbial load assessment was performed on steamed tamarillo fruit, juice and chutney using the total plate count method. Samples were serially diluted in sterile saline water to bring the microbial concentration within a countable range. Samples were subjected for 5days with different concentrations. Colony counts were manually recorded and expressed as CFU/g using standard calculations.

The cytotoxicity of tamarillo fruit extract was assessed using the Brine Shrimp Lethality Test (BSLT). Extracts were tested in varying concentrations (100–1500 µL). Each test vial contained 30 shrimps in 25 mL of salt solution mixed with the extract. A blank control (shrimp in saline only) and a positive control (1 mg/mL of known toxicant potassium dichromate) were

used for comparison. Mortality and morphological changes were observed at multiple time intervals (1, 2, 4, 6, and 24 hours). After 24 hours, lethality percentage was calculated for each concentration. This study aimed to determine whether tamarillo extract exhibits any toxic effect, contributing to the safety profiling of the fruit.

4. Quantitative phytochemical profiling and functional activity of fresh and processed tamarillo extracts

Phenols, flavonoids, glycosides and carotenoids were quantified in methanol extracts using UV Spectrophotometer. Total phenolic content of fresh and processed samples of tamarillo was determined and gallic acid as the standard and measured at 725nm (Diep *et al*., 2020). Total flavonoid determination was performed with aluminium chloride, quercetin served as the standard and taken the readings at 450nm in UV Vis spectrophotometer (Kumar, 2013). Glycoside content was determined in which Securidaside was the standard used and read at 495nm (Badri, 2023). Carotenoid content was quantified with standard carotenoid and water saturated butanol and read at the wavelength of 450nm (Syu, 2023). The anti-inflammatory potential of tamarillo fruit extract was assessed using protease inhibition assay and protein denaturation inhibition assay. Absorbance values were measured at specific wavelengths to calculate the percentage of inhibition in both methods. Standard drugs (aspirin and phosphate buffer) were used as controls for comparison, and all experiments were performed in triplicates to ensure its accuracy (Gobikanila and Jeyaramraja, 2024). DPPH (1-Diphenyl 2-picryl hydrazyl) assay was carried out to analyse the antioxidant activity. Five different concentrations 20-100µl were taken with DPPH solution and the absorbance was read at 517 nm by UV-Vis Spectrophotometer. The inhibition was calculated and IC50 value also recorded (Mutalib *et al,*.2017).

5. Cytotoxic activity of fresh and processed tamarillo extracts in cervical cancer cell lines

HeLa cell lines was used to evaluate the cytotoxicity and viability of cells with different sample extracts from tamarillo. The HeLa cell line was procured from the National Centre for Cell Science (NCCS) in Pune, India. Cells were cultivated in a medium supplemented with DMEM, 10% inactivated foetal bovine serum (FBS), penicillin, streptomycin, and incubated at 37ºC with 95% humidity. Trypsin EDTA was used to trypsinize the cells once they were 90% confluent in order to prepare them for further analysis. MTT assay was used to measure the viability of cells in order to produce the amount of purple formazan (Hamsa *et al*., 2022).

Cells were seeded in 96-well plates for 24 h, 48h and 72h treatment, before the addition of samples. Cells were separated into different concentrations as 25 µg, 50 µg, 75 µg, 100 µg and 125 µg. Treatments included freeze-dried tamarillo with peel, chutney, fresh methanol and aqueous extracts, and steamed tamarillo, compared to untreated control and standard drug etoposide. The absorbance was measured at 650nm in a microtiter plate reader. By contrasting the OD of the treated cells with the control, the dose-response curve was plotted. An estimated 50% inhibition of cell growth at a concentration was found (IC50). The MTT assay is a preliminary study to find out whether the tamarillo sample has anticancer property. The cell cycle arrest, apoptosis and ROS was carried out by flow cytometry.

CHAPTER IV- RESULTS AND DISCUSSION

- Fruit weight was noted before and after drying the samples. The results showed that cabinet drying, sun drying and freeze drying were best for the maximum yield after drying and freeze-drying emerged as the effective method for preserving the overall nutritional profile of *Solanum betaceum* Cav. (Adewale, 2017). Shade drying was not recommended because excessive moisture in the fruit lead to spoilage. Though spray drying produces low moisture content and high-quality products, continuous operation may lead to bioactive compounds loss due to highly soluble clear liquid. Sample yielding after drying indicated there was a significant difference observed on the drying methods ($p < 0.01$), based on paired t-test.
- Cooking altered the weight of tamarillo fruit subjected to moist and dry heat methods. Simmering caused the weight loss, followed by boiling, pressure cooking, and steaming. The roasted sample experienced the largest decrease, from 50g to 27.8g. Additionally, frying led to further weight loss due to water evaporation. Paired t-test analysis revealed significant weight reduction ($p < 0.01$) after roasting, indicating appreciable cooking loss under both moist and dry heat conditions (Vintila *et al*., 2016).
- Both tamarillo chutney and juice were similarly scored well with their appearance, color and texture/consistency. Cooked samples were characterized for their sensory attributes, indicated that there was no significant difference in overall acceptability of the cooked tamarillo (Puwandari *et al*., 2021).
- Fresh tamarillo exhibited a high moisture content of 81% in the samples which indicated a high perishability. Nutrient composition shows that ash content (10.2%) reflects quantity of total mineral profile. The low carbohydrate content (7.25g) translated to low energy

(46.7kcal) value. Notably, the high dietary fibre (47.3g) content offers potential benefits for digestive or gut health and may reduce the risk of coronary heart disease (CHD) and certain cancers. The results exhibited 4.28mg of iron content in tamarillo may be a beneficial nutrient for women. Vitamin C content of tamarillo, is an essential antioxidant primarily acquired from the fruits, plays a role in disease prevention. Furthermore, beta-carotene (832mcg), doubled antioxidant activity had been found suggested tamarillo may be a valuable source for individuals at risk of vitamin A deficiency. ANOVA revealed significant differences ($p < 0.01$). Fresh samples had notably higher levels of vitamin C, dietary fibre and β-carotene (Diep *et al*., 2020).

- The percentage of nutrient retention in tamarillo fruit subjected to different cooking methods of moist heat cook. Comparing to the nutrient content of moist heat cooked tamarillo the percentage of nutrient content is more retained in steam cooked samples than other cooking. Hence, steaming was assumed as the greatest nutrient retaining cooking method. During steaming, there is less contact between water and fruit, that reasons low soluble substance loss.
- A qualitative analysis of fresh and processed tamarillo extracts revealed the presence of various phytochemicals shown in the heatmap. Notably, the methanol extract exhibited appreciable amounts of flavonoids, glycosides, carotenoids and phenolic compounds. Aqueous and ethanol extracts also contained a range of phytochemicals including sterols, anthraquinones, anthocyanins, proteins and carbohydrates. The phytochemical presence contributes to a wide range of biological activities including antibacterial, anti-inflammatory and anticancer effects and also antioxidant play a role in reducing oxidative stress (Viera *et al.,* 2022 and Tung, 2022).
- Fourier Transform -Infrared Spectroscopy spectra used to identify the presence of bioactive components of tamarillo samples including: OH alcoholic/phenolic compounds the peaks obtained from the wavelength of 3695cm naturally occurred and possess antioxidant, antimicrobial and anti-inflammatory effects. The peaks observed at 1735-C=O (Carboxylic acids, esters)- a fatty acid crucial for maintaining and regulating nutrients. Aromatic ring was present at 1595, particularly found in flavonoids play a significant role in human health by exhibiting antioxidant, anti-inflammatory and properties. Aromatic C-H on 816 offers antioxidant and anti-inflammatory properties.
- Gas Chromatography-Mass Spectrometry analysis of tamarillo fruit extract revealed a diverse range of phytochemical compounds with potential health benefits. Key

compounds identified include β-Bisabolene, cis-9-hexadecenoic acid, eicosane, palmitic acid, each known for its distinct biological properties. β-Bisabolene enhances the absorption of β-carotene, contributing to improved nutraceutical value and also possesses antioxidant and antimicrobial properties. cis-9-Hexadecenoic acid and n-hexadecanoic acid (palmitic acid) are fatty acids involved in anti-inflammatory, antioxidant, and antimicrobial functions, as well as cell membrane integrity and energy storage. Eicosane, a 20-carbon polyunsaturated fatty acid, plays roles in inflammation regulation, glucose metabolism. Monoterpenoids, detected in trace amounts, showed anti-inflammatory, and neuroprotective potential. Dotriacontane, eluted in the profile, exhibited antimicrobial, antioxidant activities. Compounds like Isobutyric acid, 2-pinen-10-yl ester demonstrated a combination of anti-inflammatory and anticancer potential (Singh, 2023).

- The inhibition zones observed in the study confirmed their effectiveness. At a concentration of 40 µl, the fresh fruit extracts produced average zones of inhibition measuring 11 mm against *S. aureus* and 9–10 mm against *E. coli*. Among the processed forms, tamarillo chutney showed the highest antibacterial activity, with inhibition zones of 16 mm (*S. aureus*) and 20 mm (*E. coli*). Similarly, tamarillo juice recorded 18 mm and 17 mm zones, while steamed tamarillo exhibited 16 mm and 20 mm inhibition against *S. aureus* and *E. coli*, respectively. These results suggest that processed tamarillo exhibit enhanced antimicrobial properties against both Gram-positive and Gram-negative bacteria (Hungund *et al*., 2025).
- Microbial load analysis showed a clear difference in the shelf stability of tamarillo samples over five days. Initially, it had low microbial counts, but by day five, the chutney exhibited a significantly higher microbial growth, indicating it is more susceptible to spoilage. In contrast, tamarillo juice maintained comparatively lower microbial levels, suggesting better inherent stability. When compared to previous studies, the results highlight that improper handling, cross-contamination, and lack of preservation methods like pasteurization can lead to higher microbial loads in fruit (Mandha *et al*., 2023). Proper processing and cold storage are essential to enhance the shelf-life. This analysis suggested that microbial load of the fruit sample should not exceed 10,000 CFU/ml, in accordance with the microbial safety standards set under the Prevention of Food Adulteration (PFA) Act, 1955, and the Fruit Products Order (FPO), 1955. This limit ensures the microbiological safety and quality of the product for human consumption.

- The toxicity of tamarillo extract was tested using the brine shrimp lethality assay at different concentrations from 100 to 1500 µg/mL. At lower concentrations (100–250 µg/mL), there was no shrimp death, showing the extract is not toxic. As the concentration increased (500–1500 µg/mL), the number of dead shrimps also increased. At the highest concentration (1500 µg/mL), about 50% of the shrimp died within 24 hours. This shows that toxicity increases with higher doses, but it is relatively safe at lower levels**.**
- Quantitative analysis showed that fresh tamarillo had the highest total phenolic content (95 mg GAE/100 g), followed by steamed (88.5 mg GAE/100 g) and freeze-dried whole tamarillo (56.4 mg GAE/100g). Phenolic compounds in tamarillo are known for their strong antioxidant properties, with proven benefits like reducing inflammation, supporting immunity and preventing chronic diseases (Chen *et al.,* 2025). Steamed tamarillo (47.3µg/100g) had the highest flavonoid content followed by freeze-dried tamarillo whole (45.5µg/100g). Flavonoids are powerful antioxidants that help prevent diseases by reducing oxidative stress. Their presence in tamarillo supports various health benefits, including anti-inflammatory, antibacterial and anticancer effects. Regular consumption of tamarillo may help protect cells and improve overall health due to its rich flavonoid content (Asih *et al*., 2023). The study showed that freeze-dried tamarillo whole (16.23µg/100g) had the highest glycoside content followed by steamed (14.53µg/100g) and freeze-dried chutney (12.43µg/100g). Glycosides naturally occurring in plants are important for medicinal use due to their biological activity. Their presence, along with flavonoids and phenolics enhances the antioxidant potential of tamarillo which help to combat oxidative stress and prevent diseases. These findings support tamarillo as a valuable source of health-promoting compounds. Fresh tamarillo showed the highest carotenoid content (0.96 mg βCE/g), followed by steamed and freeze-dried tamarillo samples (Kytidou *et al*., 2020). Carotenoids, especially β-carotene confirms the antioxidants content that reduce oxidative stress, inflammation and the risk of chronic diseases like heart disease and cancer. Carotenoids can prevent damage to DNA and human cells and β-carotene helps mitigate apoptosis, inflammation and overall oxidative stress (Chen *et al*., 2025).
- The DPPH assay confirmed that fresh tamarillo extract (IC50- 25.72 µg/mL) has strong antioxidant activity, compared with the standard ascorbic acid (Luciana *et al*., 2024). This high activity is likely due to β carotene, phenolic compounds and vitamin C content of

tamarillo. The significant difference ($p < 0.001$) highlighted the potential of tamarillo as a powerful natural antioxidant and a promising nutraceutical fruit.

- Tamarillo extract showed strong anti-inflammatory activity in the protease inhibition and protein denaturation assays, with the standard drug aspirin at certain concentrations. Inhibition ranged from 15–64.7% and 18.5–77%, respectively, indicating the effectiveness of tamarillo.
- Cell viability percentage on different dose and time dependent treatment with the five different samples of tamarillo along with standard and control. Cell viability decreased in a dose and time dependent manner, with IC50 values ranging from 38.2, 24.3. 23.3, 34.3, 32.9 microgram in freeze dried whole fruit, freeze dried fruit chutney, fresh tamarillo with aqueous and methanol and steamed respectively at 72 hours treatment.
- Flow cytometry analysis revealed that tamarillo fruit extracts particularly fresh and steamed tamarillo extracts arrest the cell cycle mainly at the mitotic phases. Untreated cells showed normal cell cycle progression, while treated cells displayed significant arrest, indicating the ability of tamarillo for inhibiting the cell proliferation.
- Annexin V-FITC staining confirmed that tamarillo extracts induce apoptosis. The results revealed a significant increase in early apoptotic cells, especially in samples treated with fresh tamarillo and freeze-dried tamarillo chutney. These findings highlight the strong antiproliferative effect of tamarillo, suggesting its potential as a natural anticancer agent that promotes programmed cell death (Kavithaa *et al*., 2016). All treatments promoted apoptosis with minimal necrosis indicating controlled cell death. Fresh aqueous and freeze-dried chutney showed the strongest apoptotic and anticancer effects with the highest early apoptosis and lowest cell viability.
- This study showed that tamarillo extracts increase reactive oxygen species which causes stress in the cells and leads to cell death (apoptosis). This increase in ROS also caused damage to the mitochondria the part of the cell that gives it energy. This suggests that tamarillo kills cancer cells by targeting their energy source (Arumugam *et al*., 2021). Overall, these results show that tamarillo has strong natural antioxidant and anticancer properties. Fresh tamarillo aqueous extract showed the most effective cell death, nearly matching the standard drug etoposide followed by tamarillo methanol extract with slightly less potency. Freeze dried tamarillo chutney also demonstrated a strong apoptotic effect, while steamed tamarillo extract showed moderate activity.

CHAPTER V- SUMMARY AND CONCLUSION

- Steaming retained more nutrients moist heat methods due to minimal water contact.
- Fresh tamarillo had moderate acceptance, chutney and juice scored well for appearance, color and texture. No significant difference in acceptability among cooked forms was seen.
- Methanol extracts were rich in flavonoids, glycosides, carotenoids, phenolics and other extracts contained sterols, anthraquinones, anthocyanins, proteins and carbohydrates.
- Screening of phytonutrients identified antioxidant and anti-inflammatory functional groups aromatic ring and other bioactive compounds with antimicrobial and anticancer potential.
- Tamarillo Chutney had higher microbial growth by day 5, juice showed better stability. Safe microbial load < 10,000 CFU/ml suggested by (PFA, 1955 and FPO, 1955).
- Phenolics and carotenoids were higher in fresh tamarillo extract, steamed had highest flavonoids, freeze-dried whole contain more glycosides.
- Fresh tamarillo extracts revealed strong DPPH radical scavenging activity ($p < 0.001$).
- Potent cytotoxicity against cervical cancer cells. Reduced colony formation induced G_0–G_1 cell cycle arrest, reactive oxygen species increase and mitochondrial damage indicated apoptosis induction. Fresh aqueous tamarillo extracts most potent cytotoxic effect comparable to reference drug etoposide.
- Tamarillo is a rich source of phenolic, flavonoid and carotenoid with potent antioxidants, anti-inflammatory and anticancer properties. Inclusion of tamarillo in the diet may support human health and aid in cervical cancer prevention. Further research on *in vivo* study, public awareness on cancer risks and early screening are essential for effective prevention and management.

REFERENCES

1. Bray, F., Ferlay, J., Soerjomataram, I., Siegel, R. L., Torre, L. A., & Jemal, A. (2018). Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA: a cancer journal for clinicians*, *68*(6), 394-424.
2. Kavithaa, K., Paulpandi, M., Padma, P. R., & Sumathi, S. (2016). Induction of intrinsic apoptotic pathway and cell cycle arrest via baicalein loaded iron oxide nanoparticles as a

competent nano-mediated system for triple negative breast cancer therapy. *RSC advances*, *6*(69), 64531-64543. https://doi.org/10.1039/C6RA11658B

3. Asih, I. A., Manuaba, I. B. P., Berata, K., Rita, W. S., & Suirta, W. (2023, May). In Vivo Evaluation Of Antioxidant Activity Of Flavonoid Glycoside Extract FromTamarillo (Solanum betaceum Cav). In *IOP Conference Series: Earth and Environmental Science* (Vol. 1177, No. 1, p. 012039). IOP Publishing. 10.1088/1755-1315/1177/1/012039
4. Borowski, J., Narwojsz, A., Borowska, E. J., & Majewska, K. (2015). The Effect of Thermal Processing on Sensory Properties, Texture Attributes and Pectic Changes in Broccoli. *Czech Journal of Food Sciences*, *33*(3).
5. Chen, S.-Y.; Zhang, Q.-F.; Shen, H.-S.; Lin, S.-D. Metabolic Syndrome Prevention Potential of Tamarillo: Phytochemical Composition, Antioxidant Activity, and Enzyme Inhibition Before and After Digestion. Foods 2025, 14, 1282. https://doi.org/10.3390/foods14071282
6. Mandha, J., Shumoy, H., Matemu, A. O., & Raes, K. (2023). Characterization of fruit juices and effect of pasteurization and storage conditions on their microbial, physicochemical, and nutritional quality. *Food Bioscience*, *51*, 102335. https://doi.org/10.1016/j.fbio.2022.102335
7. Hungund, B. S., Tennalli, G. B., Hegde, N. P., Haripriya, G., & Yallappa, S. (2025). Phytochemical Screening, GCMS-LCMS Analysis of Bioactive Compounds from Methanolic Extract of Eichhornia crassipes: In vitro Cytotoxic Effect against MCF7 Cell Line. *Asian Journal of Chemistry*, *37*(6), 1367–1377. https://doi.org/10.14233/ajchem.2025.33738
8. Tung Thanh Diep, Elaine C. Rush & Michelle Ji Yeon Yoo (2022) Tamarillo (Solanum betaceum Cav.): A Review of Physicochemical and Bioactive Properties and Potential Applications, Food Reviews International, 38:7, 1343-1367, https://doi.org/10.1080/87559129.2020.1804931
9. Viera, W.; Samaniego, I.; Camacho, D.; Habibi, N.; Ron, L.; Sediqui, N.; Álvarez, J.; Viteri, P.; Sotomayor, A.; Merino, J.; et al. Phytochemical Characterization of a Tree Tomato (Solanum betaceum Cav.) Breeding Population Grown in the Inter-Andean Valley of Ecuador. Plants 2022, 11, 268. https://doi.org/10.3390/plants11030268
10. Vintilă, I. (2016). Typical traditional processes: cooking and frying. In *Regulating safety of traditional and ethnic foods* (pp. 29-62). Academic Press.

11. Diep, T., Pook, C., & Yoo, M. (2020). Phenolic and anthocyanin compounds and antioxidant activity of tamarillo (Solanum betaceum Cav.). Antioxidants, 9(2), 169.
12. Syu, P.-C.; Zhang, Q.-F.; Lin, S.-D. Physicochemical, Antioxidant, Sensory, and Starch Digestibility Properties of Steamed Bread Fortified with Tamarillo Powder. Foods 2023, 12, 2306. https://doi.org/10.3390/ foods12122306
13. Gobikanila, K., Jeyaramraja, P.R. Throwing light on the antidiabetic, anti-inflammatory and antioxidant nature of the leaves of tree tomato (Solanum betaceum Cav.). Discov Med 1, 55 (2024). https://doi.org/10.1007/s44337-024-00061-3
14. Hamsa, D., Swathi, K., Balusamy, S. R., & Sumathi, S. (2022). Degalactotigonin induces cytotoxicity and cell cycle arrest in triple negative breast cancer cells (MDA MB 231). Journal of Applied Pharmaceutical Science, 12(11), 157-168.
15. Adewale O. Omolola, Afam I. O. Jideani & Patrick F. Kapila (2017) Quality properties of fruits as affected by drying operation, Critical Reviews in Food Science and Nutrition, 57:1, 95-108, https://doi.org/10.1080/10408398.2013.859563
16. Viera, W.; Samaniego, I.; Camacho, D.; Habibi, N.; Ron, L.; Sediqui, N.; Álvarez, J.; Viteri, P.; Sotomayor, A.; Merino, J.; et al. Phytochemical Characterization of a Tree Tomato (Solanum betaceum Cav.) Breeding Population Grown in the Inter-Andean Valley of Ecuador. Plants 2022, 11, 268. https://doi.org/10.3390/plants11030268
17. Tung Thanh Diep, Elaine C. Rush & Michelle Ji Yeon Yoo (2022) Tamarillo (Solanum betaceum Cav.): A Review of Physicochemical and Bioactive Properties and Potential Applications, Food Reviews International, 38:7, 1343-1367, https://doi.org/10.1080/87559129.2020.1804931
18. Diep, T. T., Pook, C., Rush, E. C., & Yoo, M. J. Y. (2020). Quantification of carotenoids, α-tocopherol, and ascorbic acid in amber, mulligan, and laird's large cultivars of New Zealand tamarillos (Solanum betaceum Cav.). Foods, 9(6), 769. https://doi.org/10.3390/foods9060769
19. Diep, T. T., Pook, C., Rush, E. C., & Yoo, M. J. Y. (2020). Quantification of Carotenoids, α-Tocopherol, and Ascorbic Acid in Amber, Mulligan, and Laird's Large Cultivars of New Zealand Tamarillos (Solanum betaceum Cav.). Foods, 9(6), 769. https://doi.org/10.3390/foods9060769